NITROGEN - SOURCES, TRENDS, PLACEMENT AND RELATIVE VALUE

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Nitrogen fertilization of Western Canadian crops was introduced as a possible farm management practise by Cominco (Consolidated Mining and Smelting Company Ltd.) starting in 1932. The source of nitrogen was ammonium sulphate. Ammonium nitrate was introduced as a nitrogen fertilizer by Cominco in 1943-44 fertilizer season. Anhydrous ammonia was initially introduced in the prairies as a fertilizer by Cominco in 1954-55 but did not gain popularity as a fertilizer until the mid 1960's.

Initial acceptance of anhydrous ammonia as a nitrogenous fertilizer can be traced to southern Alberta and the distress pricing practises of the manufacturers during that period of time. Urea was introduced as a fertilizer by Cominco during 1960 and by Sherritt Gordon Mines Ltd. in 1962. Solution fertilizers were first introduced by Cominco in 1965 in southern Alberta. However, present popularity of this fertilizer is a direct result of the marketing efforts of Simplot during the late 1960's.

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Nitrogen Fertilizer Trends

Traditionally, ammonium nitrate is regarded as the most acceptable nitrogen fertilzer for a wide variety of soil-crop conditions provided all sources are equally priced per unit of nitrogen. Changing market conditions, manufacturing conditions, distribution costs and better agromonic information are changing the nitrogen supply picture somewhat. The changing patterns of nitrogen use on the prairies is illustrated in Figure 1 and table 16.

The future supply situation for the prairies would appear to be one of static supplies of ammonium nitrate as the fertilizer nitrogen market grows and vastly increased supplies of urea. We can therefore expect that urea will command an increasingly larger portion of the nitrogen market in the future. It is expected that the use of anhydrous ammonia will also continue to grow because of a high farmer preference for this product once established in an area, although its growth will be much less rapid than in the case of urea because of the high cost of establishing retail facilities. As in the case of ammonium nitrate, growth in the use of ammonium sulphate and solution fertilizers will be restricted due to supply problems.

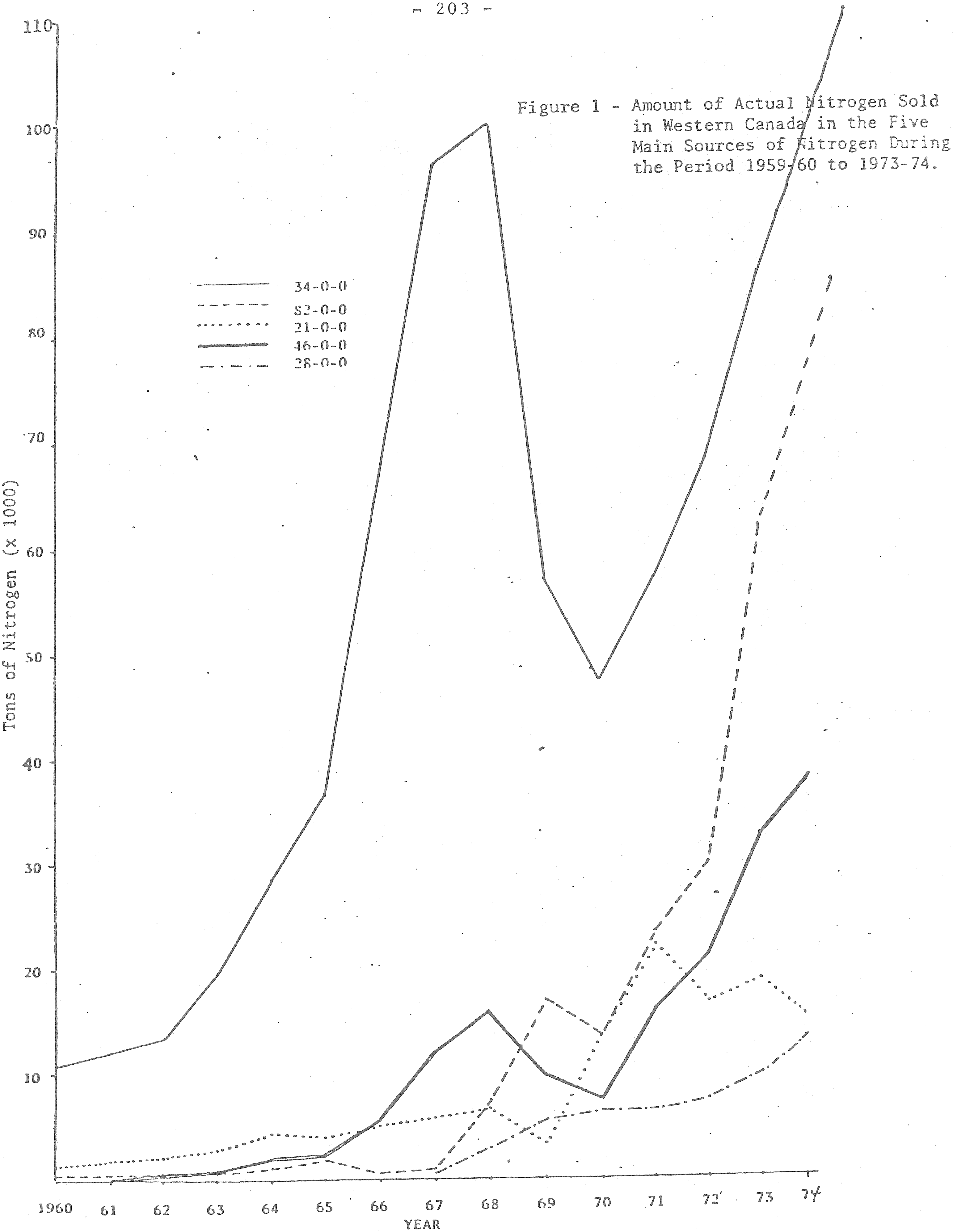
Fertilizer Costs - Manufacturing to the Farm

The cheapest source of nitrogen for the farmer will be urea. This partly results from the fact that urea has a significantly higher analysis than any of the other dry nitrogen fertilizers, therefore, savings in freight, storage, handling and application costs can be passed on to the farmer. Secondly, much of the urea available in the future will be produced in large plants of modern design. Economies of scale should reduce the cost of nitrogen relative to ammonium nitrate which will continue to be produced in smaller plants of older design and technology.

Lower analysis means that 35% more nitrate than urea would have to be shipped, handled, stored and applied to get the equivalent amount of nitrogen.

Ammonia is a very concentrated fertilizer (82%N) that is cheapest to produce but costly to handle and distribute because it is a dangerous gas that is kept liquid through use of refrigeration or pressure. In areas of high ammonia use such as the U.S. midwest where levels of ammonia application are high and anhydrous ammonia enjoys a long spring and fall application season as well as being used for sidebanding during the growing season, high overhead costs at the retail can be spread over many tons of ammonia.

Figure 1 - Amount of Actual Nitrogen Sold in Western Canada in the Five Main Sources of Nitrogen During the Period 1959-60 to 1973-74.



Consequently, it is expected that in these areas ammonia will continue to be cheaper than in western Canada.

Ammonia requires more ideal soil and climatic conditions for application than the dry fertilizers. Under prairie conditions where levels of application are relatively low and ammonia application is limited to a short spring and fall period, either of which could be plagued by uncooperative weather conditions, it is often difficult to handle sufficient ammonia through the retail facility. Consequently, higher retail overhead and distribution costs in western Canada than experienced in high use areas should make this fertilizer more expensive to the farmer than urea but still considerably cheaper than ammonium nitrate.

Agromonic Factors

Faced with the competitive nature of the fertilizer market, the manufacturer could logically decide that urea is the only source of nitrogen that should be provided because the lower overall manufacturing, distributing and application costs would make urea the cheapest source of nitrogen applied to the farmers land. However, this ignores the fact that the agronomic usefulness of a fertilizer varies with different soil-crop situations. Each of the five principal nitrogen sources has its own particular characteristics that give each advantages and disadvantages in the wide variety of soil-crop and management situations encountered on the prairies. Agronomically, each of the major sources will be in demand and should be recommended for certain farming conditions.

Agronomic Research

Over the past eight years, WCFL has engaged in a field research program of fertilizer evaluation. In the more recent years, a significant portion of this research effort as well as most of the supported research at universities and research stations has been concentrated on gathering information on the relative agronomic usefulness of the various nitrogen fertilizers with particular emphsis on urea and ammonium nitrate.

It is the opinion of the writers that a great deal more research has to be conducted on defining the conditions under which each of the major nitrogen sources work best.

Nitrogen Sources - Broadcast for Annual Crops (Alberta)

In the fall of 1973 and spring of 1974 a total of three plots were established on stubble and seeded to barley in the Calgary-Olds area. The results ar summarized in Table 1.

In these trials urea was almost as effective as ammonium nitrate (ie. 96-97%), while ammonium sulphate was only 89-90% as effective. There was a strong interaction between time of application and yield response to calcium nitrate. It would appear that under the early growing season conditions experienced in 1974 (cool, late spring, moisture supply good, but not excessive), nitrogen in the nitrate form was most beneficial while this form of nitrogen was least effective under the conditions expereinced in the fall of 1973 (ie. wetter than normal). Spring was the most beneficial time to apply nitrogen for all sources and locations (ie. fall applied 72% as effective as spring applied nitrogen) except for fall applied 34-0-0 at the driest location (ie. east of Calgary).

Table 1. Effect of Nitrogen Source and Time of Placement on Yield of Barley.

	Yield Increase (Cwt/acre)		
	Fall	Spring	Average
Ammonium nitrate	7.7	9.9	8.8
Urea	7.4	9.6	8.5
Calcium nitrate	6.2	10.8	8.5
Ammonium sulphate	6.9	8.8	7.8
Average	7.1	9.8	

Note: Nitrogen applied at 60 lbs.N/acre.

The results of four trials established in the north-central portion of Alberta and reported on by Malhi and Nyborg (1974) are presented in Table 2. The researchers reported that these trials were conducted during a period (Oct./73-Aug./74) when rainfall and soil moisture was above normal for the region and probably conducive to larger than normal over-winter losses of fall applied nitrogen. Using the urea and ammonium nitrate data, fall applications were only 61% as effective as spring applications . Under these conditions fall urea was 110% as effective as ammonium nitrate, but only 89% as effective in the spring of the year. This suggests that under conditions of above normal moisture some benefits can be expected from having the nitrogen in the ammonium form for fall application although spring is the preferred time and ammonium nitrate the preferred source. Calcium nitrate was by far the least effective when fall applied.

It is quite apparent that incorporating the nitrogen was beneficial and a further benefit was obtained by banding the nitrogen near the seed row. By examining the data presented in Table 2, it can be seen that this trend was present for both spring and fall applied nitrogen. Incorporation increased the yield responce to 34-0-0 by 1.5 Cwt/acre while urea benefited by 2.6 Cwt/acre.

Table 3. Effect of Ammonium Nitrate and Urea and Their Method of Placement on Yield of Barley (Malhi and Nyborg, 1974)

	Yield Increase (Cwt/acre)		
	34-0-0	46-0-0	Average
Surface Broadcast	7.9	7.2	7.6
Broadcast and Incorporated	9.4	9.8	9.6
Subsurface Banded	11.1	10.8	11.0

Nitrogen Sources - Broadcast for Annual Crops (Manitoba)

A great deal of information has been collected at the University of Manitoba on the relative value of spring and fall broadcast nitrogen. Ridley (1973) reported on broadcast nitrogen applied to calcareous and non-calcareous soils in the Red River Valley. At the locations with higher rates of application (ie. 52 lbs.N/acre) on calcareous and non-calcareous soils, urea was 78% and 97% respectively as effective as ammonium nitrate and 86% and 89% respectively in the trials with the lower rate of nitrogen applied (ie. 22 lbs.N/acre). It would appear therefore that urea is a less efficient source of nitrogen on calcareous soils. In both soil types, fall applied nitrogen was 60% as effective as spring applied nitrogen.

Ridley (1974) also reported one trial where four different nitrogen sources were compared at three different times of application (see Table 5). Nitrogen broadcast in the early fall was 86% as effective as spring applied nitrogen. Late fall applications were only 57% as effective. The one possible explanation for this difference is that the late fall applied nitrogen may have been kept nearer the surface by frozen soil and was therefore more susceptible to spring run-off losses when flooded temporarily with snow melt.

Table 4. Effect of Nitrogen Source and Timing on Yield of Barley Grown on Calcareous and Non-calcareous Soils (Ridley, 1973).

	Yield Increase (Cwt/acre)				
	Calcareous Soils		Non-calcareous Soils		
	34-0-0	46-0-0	34-0-0	46-0-0	Average
Fall	5.4	3.0	6.5	5.6	5.1
Spring	9.0	8.3	9.2	9.7	9.0
Average*	7.2	5.6	7.8	7.6	
Fall	6.6	4.8	4.1	2.4	4.5
Spring	8.2	8.0	5.6	6.3	7.0
Average**	7.4	6.4	4.8	4.3	

* Average of 4 calcareous and 3 non-calcareous trials, nitrogen broadcast at 52 lbs.N/acre.

**Average of 3 calcareous and 3 non-calcareous trials, nitrogen broadcast at 22 lbs.N/acre.

Table 5. Effect of Time of Application and Nitrogen Source on Yield of Barley (Ridley, 1974)[1]

	Yield Increase (Cwt/acre)			
	Early Fall	Late Fall	Spring	Average
34-0-0	9.1	6.2	11.1	8.8
46-0-0	8.6	4.3	9.3	7.4
21-0-0	6.2	5.3	8.2	6.6
28-0-0	7.0	4.7	7.6	6.4
Average	7.7	5.1	9.0	

1 Trial located in the Red River Valley on a calcareous Lakeland loam soil, nitrogen applied at 52 lbs.N/acre.

Partridge and Ridley (1974) reported that there was a difference between the value of fall applied nitrogen on the lowland and upland soils of Manitoba (see Table 6). From the data they reported, it was apparent that in the poorly drained lowlands, fall applied nitrogen was only 62% as effective as spring applied nitrogen for the eight trials conducted between 1968-74. For one of those eight trials conducted in 1974, fall applied nitrogen was only 32% as effective as spring applied nitrogen. This is probably directly related to the very wet late fall and early spring conditions experinced that year.

In the uplands, for the 5 trials conducted between 1970 and 1973, the relative value of fall applied nitrogen was 80%. For the five trials conducted in the uplands during 1974, fall applied N was 102% as effective as spring applied nitrogen. This improved performance of fall applied nitrogen experienced in 1974 is probably directly attributable to the early growing season moisture conditions which tended to be very dry in the upland area. As a result, fall applied nitrogen moved down the profile by snow melt and early spring rains and was positionally available, whereas spring broadcast nitrogen could have been "stranded" in the dried-out upper 2" of soil where there was very little root growth early in the growing season. It could be speculated that this better performance of fall applied nitrogen could be expected in the better drained soils in the Brown, Dark Brown and Thin Black soils in most years and particularly in years that tend to be dry during the early growing season.

Table 6. Response of Barley to Spring and Fall Applied Nitrogen in the Manitoba Uplands and Lowlands (Ridley and Partridge, 1973)

	Yield Increase (Cwt/acre)	
	Fall	Spring
	Lowlands	
1968-74 (Average of 8 Trials)	7.1	11.5
1974 (1 trial only)	2.2	7.3
	Uplands	
1970-73 (Average of 5 trials)	5.2	6.5
1974 (Average of 5 trials)	4.2	4.1
Average of 10 trials	4.7	5.3

For six trials conducted between 1968-71, Partridge (1974) reported the average yield of surface broadcast nitrogen was 20.4 Cwt/acre and 20.2 Cwt/acre for the broadcast and incorporated indicating no value for working the nitrogen into the soil. This is not in agreement with the results obtained by Malhi and Nyborg (1974) who worked with soil and weather conditions very similar to those expected in Manitoba. In 1974, the results, particularly at the upland sites were quite different (see Table 7).

It is curious that under conditions of excess moisture in Alberta and a dry growing season in Manitoba, the benefits of incorporation were most evident. In the Manitoba data presented in Table 7, there does appear to be tendency in the lowlands to benefit from incorporation of nitrogen in the fall of the year, but the opposite appears to be true in the spring. It could be speculated that fall incorporation reduces spring surface run-off losses, whereas spring incorporation into a wet soil encourages dentrification losses. Incorporation at the upland sites appeared to be beneficial, at least in the one year (1974) when most of the upland data was collected.

Table 7. Effect of Incorporation of Broadcast Nitrogen on Yield of Barley (Partridge, 1974)

	Yield Increase (Cwt/acre)			
	Non-incorporated		Incorporated	
	Fall	Spring	Fall	Spring
	Lowlands			
1968-74 (8 trials)	6.7	12.2	7.4	10.7
1974 (1 trial)	1.5	7.0	2.5	7.2
	Uplands			
1970-71 (1 trial)	4.0	7.7	3.9	5.6
1974 (5 trials)	3.5	2.4	4.4	5.0

The relative value of fall compared to spring applications of nitrogen for the data presented in Table 4 ranged from 57% to 64% at the two levels of nitrogen application on these lowland soils. Partridge (1974) reported on the relative values of spring and fall applied nitrogen and found that for the lowlands, fall applied nitrogen only averaged 62% as effective as spring applied (see Table 6). In the uplands, fall applied was 83% as effective.

For the trials included in the data presented in Table 5, the relative value of the sources was: 34-0-0(100%), 46-0-0(84%), 21-0-0(75%) and 28-0-0(73%). The relative values for most of the Manitoba trials is summarized in Table 9. Hedlin and Soper (1965) reported that broadcast urea was slightly more than 80% as effective as broadcast nitrate and about 90% as effective if incorporated.

Research conducted at Indian Head (McIver, 1974) over a period of 9 years on Indian Head heavy clay soil indicates that fall applied nitrogen was about 10% more effective than spring applied nitrogen (Table 8). Fall applied urea was found to be 73% as effective as fall applied nitrate when both were cultivated into the soil.

Table 8. Relative Value of Spring and Fall Applied Nitrogen on Yield of Wheat on Indian Head Clay Soil Over a Period of Nine Years. (McIver, 1974)

		Yield Increase (Cwt/acre)	
Treatment	Time	1974	1966-74
40#N as 34-0-0	Spring	2.9	5.4
40#N as 34-0-0	Fall	6.2	6.0
40#N as 34-0-0	Fall(incorp)	6.5	7.1
40#N as 46-0-0	Fall(incorp)	4.5	5.2

Table 9. Relative Value of Various Nitrogen Sources for Barley on Stubble (Partridge, 1974).

	Yield Increase (Cwt/acre) and Relative Value				
	34-0-0	46-0-0	21-0-0	28-0-0	82-0-0
	Lowlands				
1968-74 (8 trials)	9.5(100%)	8.9(94%)			
1972-74 (3 trials)	7.6(100%)	7.2(95%)	6.4(84%)	6.7(88%)	
1974 (1 trial)	5.0(100%)	4.8(96%)	3.6(72%)	4.7(94%)	6.1(122%)
	Uplands				
1970-74 (10 trials)	5.5(100%)	4.4(80%)			
1970-74 (8 trials)	4.7(100%)	4.0(85%)		2.9(62%)	6.5(138%)
1974 (5 trials)	4.1(100%)	3.7(90%)	3.8(93%)	3.5(85%)	5.6(137%)

The superior performance of anhydrous ammonia in the few trials in which it was included is thought to be related to a better positional availability (ie. placed in the rooting zone of the crop). It would be expected that the advantage of 82-0-0 would be greatest in years where the soil surface dries out early in the growing season. This was confirmed in some data collected by WCFL in Alberta in 1968 (see Table 10) where preplant ammonia was compared to surface broadcast ammonium nitrate applied immediately after seeding. Under these conditions of better positional placement of nitrogen ammonia, this source was 153% as effective as ammonium nitrate.

Table 10. Effect of Ammonium Nitrate and Anhydrous Ammonia on Yield of Grain (WCFL, 1968)

Area	Rate Applied (lbs.N/acre)	Yield Increase (Cwt/acre) 34-0-0	82-0-0
Drumheller	29	3.1	9.1
Evarts	60	5.2	5.1
Eckville	60	3.8	8.0
Lacombe	40	4.0	4.0
Coaldale	60	6.4	7.7
Drumheller	40	2.1	3.8
Barons	50	0.3	0.8
Average		3.6	5.5

Nitrogen Sources - Drill-in V.S Broadcast

Soper (1973) reported that based on information collected in 16 trials, the advantage of drilling-in rather than broadcasting 13, 33 and 53 pounds of nitrogen per acre on stubble was 1.8, 6.0 and 1.0 bushels per acre respectively. For urea, based on data from eight trials, at the same rates of applied nitrogen, the yield difference in favour of broadcasting were -0.2, 0.6 and 11.9 bushels per acre.

Toews and Soper (1969) found that at 20-40 lbs.N/acre, broadcast nitrogen was only 75% as effective as drill-in nitrogen. When drilled-in at 20, 30, 40 and 60 lbs.N/acre, urea was 83%, 74%, 66% and 41% respectively as effective as ammonium nitrate. When broadcast at 20, 40, 60 and 90 lbs.N/acre the relative values were 108%, 92%, 85% and 93% respectively.

Six years of seed placement and broadcast nitrogen results obtained by WCFL are summarized in Tables 11 and 12. Urea and ammonium nitrate have been compared as nitrogen fertilizers at 35 locations for stubble crops in Alberta. The average yield increase for 30 lbs.N/acre of urea and ammonium nitrate was 4.1 and 5.8 cwt/acre (see Table 11). On the lighter textured soils, drilled-in urea was only 54% as effective as ammonium nitrate but was 91% as effective on the heavier textured soils. On the lighter textured soils, broadcast ammonium nitrate was 95% as effective as drilled-in ammonium nitrate and 93% as effective on the heavier textured soils. Broadcast ammonium nitrate was more effective than drilled-in urea (110%) on the heavier, but particularly on the lighter textured soils (176%).

In examining the data collected in 1973 and 74, drilled-in urea was 52% and 84% as effective as drilled-in urea for the two respective textural groupings. Broadcast nitrate was 163% as effective as drilled-in urea on the lighter textured soils but only 120% more effective on the heavier textured soils and 130% and 128% more effective than broadcast urea for the respective soil groupings. Noteworthy is the fact that on the heavier soils drilled-in urea out-performed broadcast urea, but the opposite was true on the lighter textured soils.

Table 11. Yield Response of Feed Grains to Source and Placement of Nitrogen on Stubble as Influenced by Soil Texture (WCFL).

	Yield Increase (Cwt/acre)			
	34-0-0(D)	46-0-0(D)	34-0-0(B)	46-0-0(B)
SL-L (15 sites)	6.7	3.5	5.7	4.4
HvL-C (7 sites)	5.8	4.9	5.9	4.6
Average[1]	6.2	4.2	5.8	4.5
SL-L (17 sites)	6.3	3.4	6.0	
HvL-C (10 sites)	7.1	6.0	6.6	
Average[2]	6.7	4.7	6.3	
SL-L (19 sites)	6.1	3.3		
HvL-C (16 sites)	5.6	5.1		
Average[3]	5.8	4.2		

Note: Fertilizer treatment 30-45-0, check 0-45-0
1. Average based on 1973 and 74 data.
2. Average based on 1972, 73 and 74 data.
3. Average based on 1969, 72, 73 and 74 data.

B - Surface broadcast
D - Drilled-in with seed

Similar information for the trials conducted on summerfallowed soils is presented in Table 12. It is apparent that drilled-in urea on summerfallow was of very little value, particularly on lighter textured soils. Although ammonium nitrate drilled-in with the seed resulted in an average yield increase of 5 bushels of barley, this was only 62-74% as effective as when surface broadcast. On the lighter textured soils, broadcast urea was only 40% as effective as similarly applied ammonium nitrate while on the heavier textured soils it was 76% as effective.

In view of these results, the practise of drilling-in some nitrogen for feed grains grown on summerfallow for a starter effect should be reconsidered. It would appear that the use of urea containing fertilizers for this purpose should be particularly discouraged. Under the relatively weed-free conditions maintained in research plots, broadcast nitrogen was found more beneficial than drilled-in nitrogen. It is expected that the value of broadcast nitrogen relative to drilled-in nitrogen would decrease in the presence of weeds.

The poorer performance of drilled-in nitrogen on summerfallow relative to stubble was not expected and is hard to explain. It could be speculated that the need for nitrogen near the seed is greater on stubble and secondly, broadcast nitrogen on stubble is often positionally unavailable due to being in the drier surface soil where the crop may not root until the surface is moistened by rainfall. This delay in availability of broadcast nitrogen on stubble would reduce the value of the broadcast nitrogen.

Table 12. Yield Response of Feed Grains to Source and Placement of Nitrogen on Summerfallow as Influenced by Soil Texture (WĆFL).

	Yield Increase (Cwt/acre)			
	34-0-0(D)	46-0-0(D)	34-0-0(B)	46-0-0(B)
SL-L (2 sites)	3.4	-0.2	3.7	1.5
HvL-C (5 sites)	2.0	0.4	4.2	3.2
Average [1]	2.5	0.1	4.0	2.4
SL-L (9 sites)	2.3	0.8	2.8	
HvL-C (14 sites)	2.7	1.4	4.1	
Average [2]	2.5	1.1	3.4	

Note: Fertilizer treatment 30-45-0, check 0-45-0
1. Average based on 1973 data.
2. Average based on 1971, 72 and 73 data.

B - Surface broadcast
D - Drilled-in with seed

It would appear that the recommendation that the nitrogen should be placed as close to the seed and applied as close to the time of seeding for maximum results is strongly biased by information collected on stubble. It also points out the need to follow up the kind of results reported by Malhi and Nyborg (1974) which showed the benefit of banding in the moist soil v.s. mixing the nitrogen into the top soil. The value of sub-surface banding is also supported by the superior performance of nitrogen applied as anhydrous ammonia.

The effect of nitrogen source on plant emergence is summarized in Table 13. Examination of data not included in the table from individual plots indicated that the crops often showed a great ability to overcome reduced germination by tillering and a large reduction in germination did not necessarily correspond to a large reduction in yield. Nevertheless, there was a definite tendency to lower germination counts where urea was the source of nitrogen rather than ammonium nitrate.

Table 13. Effect of Nitrogen Source on Plant Germination

	Relative Plant Density		
	Control	34-0-0	46-0-0
Stubble SL-L (18 sites)	100	103	83
Stubble HvL-C (14 sites)	100	100	98
Fallow SL-L (6 sites)	100	97	86
Fallow HvL-C (10 sites)	100	104	94
Average	100	101	92

Note: Fertilizer treatment for control was 0-45-0 at 100lbs/acre and two nitrogen sources were drilled-in at 30 lbs.N/acre along with the indicated phosphate.

Nitrogen Sources for Forage Crops

Information collected by WCFL on the relative value of urea and ammonium nitrate applied to grass stands at the rate of 100 lbs.N/acre for 62 site years indicated that urea was only 85% as effective as ammonium nitrate (Average yields: check—18.7, 34-0-0—35.2 and 46-0-0—32.8 Cwt/acre). When applied in the spring of the year (April, May), urea was 82% as effective as ammonium nitrate (see Table 14) and 86% as effective when fall applied (ie. October, November). Early spring was the best time to apply a nitrogenous fertilizer to a grass stand. A review of research results by Toews (1971) indicated that when applied at rates of 40 and 80 lbs.N/acre, the relative efficiency of urea compared to ammonium nitrate was 66% for fall applied treatments and 76% for spring applied treatments.

Table 14. Effect of Nitrogen Source and Tine of Application on Yield of Grass Stand.

	Yield Increase (Cwt/acre)		
	Fall	Spring	Average
34-0-0	13.3	16.0	14.6
46-0-0	11.4	13.1	12.2
Average	12.4	14.6	

Field observations indicate that the response to urea is much more variable on grass stands than when broadcast for annual crops. It has been noted that response to urea applied to forage stands can be very poor if applied during warm weather, particularly in stands with a high surface thatch cover. Bole (1975) indicated that degree of thatch cover greatly influenced urea volatilization losses but had little influence on volatilization losses from surface applied nitrate.

Research reported from southern Manitoba by Bailey (1974) indicated that the relative efficiency of urea and solution fertilizer was 93% and 39% on the sandy soil and 96% and 23% on the clay site. Relatively poor performance of 28-0-0 solution fertilizer when applied on a forage stand is predictable as it would be if applied on stubble fields with a high trash cover, however the extremely poor performance of 28-0-0 in these trials was more serious than anticipated.

Table 15. Effect of Nitrogen Source on Yield of Grass on Two Soil Types (Bailey, 1974)

	Yield Increases (Kgm./ha)*		
	34-0-0	46-0-0	28-0-0
Miniota sand	2462	2287	955
Assiniboine clay loam	2156	2071	488

* Average of data from separate plots of Brome grass, Crested Wheat grass, Timothy and Russian Wild Rye grass for two successive years. Nitrogen applied at 125 lbs.N/acre in spring of year.

Table 16. COMPARISON OF AMOUNTS OF ACTUAL NITROGEN SOLD IN VARIOUS PRODUCTS IN WESTERN CANADA DURING THE PERIOD 1959-60 TO 1973-74

YEAR	TOTAL NITROGEN	34-0-0		46-0-0		82-0-0		21-0-0		28-0-0	
959-60	11,718	10,113	(86.3%)	24	(-%)	346	(3.0%)	1,235	(10.5%)	--	
61	14,593	12,181	(83.5%)	85	(.6%)	387	(2.7%)	1,940	(13.3%)	--	
62	16,098	13,675	(84.9%)	139	(.9%)	228	(1.4%)	2,056	(12.8%)	--	
63	23,467	19,720	(84.0%)	456	(1.9%)	574	(2.4%)	2,717	(11.6%)	--	
64	35,156	28,396	(80.8%)	1,785	(5.1%)	903	(2.6%)	4,072	(11.6%)	--	
65	44,022	36,456	(82.8%)	2,078	(4.7%)	1,515	(3.4%)	3,973	(9.0%)	--	
66	76,860	66,105	(86.0%)	5,491	(7.1%)	309	(.4%)	4,955	(6.4%)	--	
67	115,070	95,974	(83.4%)	12,002	(10.4%)	829	(.7%)	5,828	(5.1%)	437	(.4%)
68	132,215	99,766	(75.5%)	15,718	(11.9%)	7,328	(5.5%)	6,623	(5.0%)	2,780	(2.1%
69	91,999	56,857	(61.8%)	9,699	(10.5)	16,809	(18.3%)	3,303	(3.6%)	5,271	(5.7%
70	87,575	47,164	(53.9%)	7,438	(8.5%)	13,419	(15.3%)	13,533	(15.4%)	6,021	(6.9%
71	122,519	56,912	(46.5%)	15,929	(13.0%)	23,281	(19.0%)	20,241	(16.5%)	6,156	(5.0%
72	142,658	68,057	(47.7%)	21,164	(14.8%)	29,937	(21.0%)	16,475	(11.5%)	7,025	(4.0%
73	208,210	85,901	(41.3%)	32,443	(15.6%)	61,748	(29.7%)	18,508	(8.9%)	9,610	(4.6%
est) 74	259,490	111,163	(42.8%)	37,481	(14.4%)	84,611	(32.6%)	14,223	(5.5%)	12,012	(4.6%

(The figures include the nitrogen used in blends but not in phosphate production)

Conclusions

1) In the 1960-61 fertilizer season ammonium nitrate which is the nitrogen fertilizer best adapted to a wide range of soil-crop situations, accounted for over 80% of the fertilizer nitrogen sold in westen Canada. In 1973-74 it accounted for about one half of that amount. In the future static supplies of ammonium nitrate in a growing market for fertilizer nitrogen will mean that this source will account for less of the nitrogen than sold in the form of urea.

2) More research is required to pinpoint soil-crop situations to which a given nitrogen fertilizer is best adapted to maximize efficiency of increasingly expensive nitrogen fertilizers.

3) The benefits of using ammonium nitrate as a fertilizer are most evident in the following situations:

(a) As a drill-in source of nitrogen particularly on light textured soils.
(b) As a drill-in source of nitrogen where higher than normal rates are applied with the seed because of adverse weed conditions.
(c) As a broadcast source of nitrogen fertilizer where the fertilizer cannot be incorporated into the soil.
(d) As a broadcast source of nitrogen fertilizer for forage crops in the Brown, Dark Brown and Black soil zones and particularly where nitrogen is being broadcast in dry warm weather (slight moisture followed by drying may be more critical) on fields with a high degree of thatch cover.

4) Incorporation of broadcast nitrogen for annual crops in the well drained upland soils should be beneficial in most years whether applied in the spring or the fall.

5) Incorporation of broadcast nitrogen for annual crops on poorly drained lowland soils is not always beneficial, particularly in the spring of the year.

6) More research needs to be conducted on placement of nitrogen in the rooting zone near the seed band in view of the excellent results obtained using anhydrous ammonia.

7) On the well drained soils of the drier regions, fall application of broadcast nitrogen should yield results similar to spring applications. On the poorly drained soils subject to flooding and higher precipitation, fall applications often yield poor results compared to spring applications.

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Question: Why does anhydrous ammonia appear so superior to ammonium nitrate?

Answer: Anhydrous when placed in the 4 - 6" soil depth is usually in moist soil, down where roots can make better use of the nutrient.